PUBLISHED BY THE NEW YORK STOCK EXCHANGE

JUNE 1961 20¢ A COPY

# THE CHALLENGE OF SPACE

# The Challenge of Space

*By* DR. HAROLD RITCHEY

*President, American Rocket Society, Vice President and Head of Rocket Operations, Thiokol Chemical Corp.*

FOR hundreds of millions of Americans and free people throughout the world who were at their TV and radio sets that morning, the age of space flight began May 5, 1961—the day they climbed into a Mercury capsule with Comdr. Alan B. Shepard, Jr., and went along on his epic ride.

Prior to this, nothing we nor the Russians accomplished—not even the orbital flight of Yuri Gagarin—attracted such universal interest nor produced such emotional impact. For the first time, the wide-eyed world awakened to the realization that man is ready to embark on the greatest journey of discovery since Columbus.

Without downgrading the importance of this feat, we should consider Comdr. Shepard's flight in the light of the tremendous task we now face in making space exploration practical. The full effect of this spectacular achievement on current space programs in this country is yet to be felt, but in my opinion the great surge of national pride it created will help accelerate this nation into an all-out effort to overtake the Russians. I would recommend that all involved in our space programs—scientists, industry and government—waste no time in preparing not only for the mammoth technical challenges to come but for a newly curious, enlightened public which will want to know not only *what* and *how* we are doing in space, but *why*.

The industry should look on this new curiosity as an opportunity to foster public understanding that beyond missiles and more powerful destructive nuclear warheads, our programs to explore space promise relatively immediate and continuing benefits—better products, more efficient ways of doing things, swifter and safer transportation, better health and a longer, more productive life. And, of course, the companies that will provide these goods and services of the future will present new investment opportunities for millions.

The stakes are momentous. President Kennedy recognized this when he asked Congress last month for an additional $7 to $9 billion over the next five years for our space program, including a manned shot to the moon. In the balance lies either new greatness and rewards for our nation and all mankind or the potential disaster of running second.

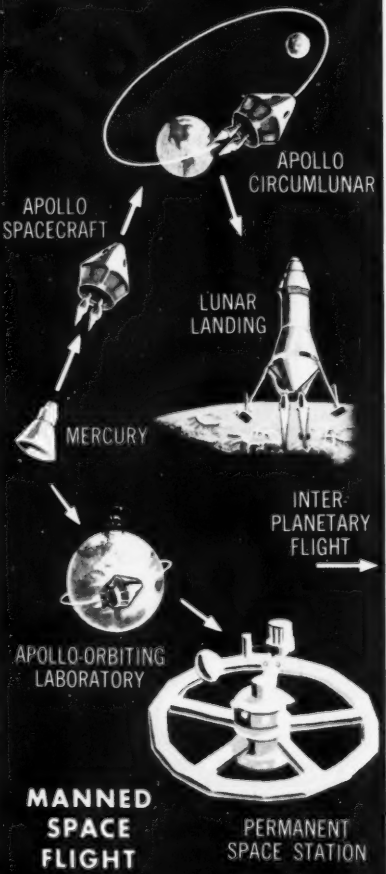
THE EXCHANGE

Second Class Postage Paid at the Post Office, New York, N. Y. THE EXCHANGE is a monthly publication of the New York Stock Exchange. William D. Horgan, Editor

Vol. XXII, No. 6 • June, 1961

*Editorial Offices*, 11 Wall St., N. Y., N. Y. Subscription: $1.50 a year; $3.50 for three years. [Please notify us of address change a month in advance, giving old and new.]

# MAN IN SPACE 1970



*By* KRAFFT A. EHRICKE

*Centaur Program Director, Convair Division, General Dynamics Corp.*

THE year is 1970 and you are aboard a spacecraft streaking away from the earth's surface. The chances are that you will probably pass through a series of telephony, television, weather, radio and navigational satellites permanently stationed in space.

Also, depending on the direction of your flight, you will probably see several satellites circling the moon in support of scientific expeditions by man to that planet, and a number of manned research and flight training space stations 300 miles or more from earth.

But the amazing advances made in exploring and conquering the unbelievably vast vacuum that is space will not be confined to these accomplishments. In the next decade man will have made giant strides in developing the means to achieve flight in space and will begin to look to the planets Venus and Mars as his goals for the 1970-1980 decade.

By 1970 we can expect the following state of development in astronautics:

1. Communication and television relay satellites at very great altitudes, probably as high as 22,000 miles (24-hour orbit) in equatorial and inclined orbits.

2. Global weather monitoring on a routine basis from television satellites circling the globe in polar or highly inclined orbits from 4,000 to 8,000 miles high.

3. Radio-navigation satellites some 1,000 miles high in equatorial and inclined orbits, serving ships at sea.

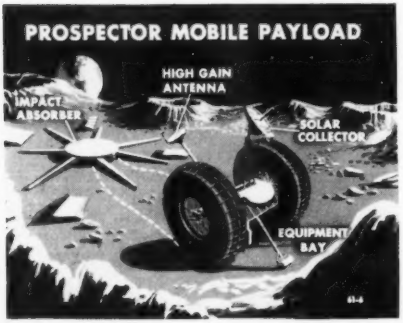
4. One or more relatively small manned space stations some 300 miles high in the equator plane for orbital flight training, life support systems development and man-conducted research in space. All or many of these satellites and space stations will be equipped with nuclear auxiliary power supply systems.

5. Satellites of the moon will have been established and landings with instrument probes on the moon will have been accomplished. Probably the first landings by man will have been achieved.

6. Man will have circumnavigated the moon using vehicles launched directly from earth's surface without orbital assembling or fueling.

7. Interplanetary probes will have covered the entire inner solar system from inside the orbit of Mercury to the asteroid belt beyond Mars. Encounter probes will have been sent to Venus and Mars and instrumented satellites of these planets will have been established. Probes may have been sent out as far as the planet Jupiter.

*Artist's concept of spacecraft for exploration of the moon.*




### New Rocket Power

Activities related to moon and interplanetary exploration will necessarily require a vast intercontinental net of tracking stations. This system could well initiate a practical step-by-step approach to more sweeping international space agreements. Sharing tracking systems, joint evaluation of scientific data, and coordinate transmission frequencies might also open the door to extended international cooperation in astronautical research and development in the next 10 years.

All of these projects will have been carried out essentially on the basis of chemical rockets, such as the ICBM boosters with advanced chemical upper stages and the 1.5 million pound thrust booster with chemical upper stages. However, a nuclear heat exchanger rocket will probably be perfected and tested in space between earth and moon during the second half of this decade, and ion rockets—which involve the conversion of electrically charged atoms into thrust or power—could be greatly advanced.

All of these achievements will not come, however, without effort and imagination; research and tests; failures and successes; determination and faith—and the investment of billions of dollars.

# MACH 3

*By* DONALD W. DOUGLAS, JR.
*President, Douglas Aircraft Company*

WITHIN the next decade, it will be possible for an American business man to check his morning mail in the office, attend a business meeting in London or Paris and return in time to catch his regular commuter train home.

Chances are, a flight to Europe and return on a supersonic transport will not take much more time than travel between his office and his suburban home.

A supersonic transport, such as those now under intensive engineering study, will be able to make a trans-Atlantic *roundtrip* in about four and one-half hours, considerably less than it now takes to cross the Atlantic in one direction.

If all of this sounds somewhat fanciful, I suggest a re-reading of newspapers and popular magazines of 1954 and 1955. They were making similar promises of "weekends in Paris" via the subsonic jet transports then on the drawing boards. What some then considered extravagant is now accepted as routine.

There is no reason to believe that predictions on supersonic transports will turn out to be any less reliable. One well-informed aviation magazine recently carried this statement: "The question is no longer, 'Will there be a supersonic transport?' but rather, 'When will supersonic service start?'"

That is another way of saying that the technical feasibility of supersonic air travel is demonstrable. Only the timing, which hinges largely on economics, remains a subject for conjecture. At Douglas, we believe the financial hurdles can be surmounted while technical feasibility is being shaped into reality.

Before reviewing the economic aspects of the supersonic transport, which our industry often abbreviates as SST, it might be interesting to take a closer look at the vehicle itself. Its speed, range, size and type of structure all have been subjected to thorough analytical study. However, design decisions may be affected by new technological progress or major

Donald W. Douglas, Jr., has been president of the Douglas Aircraft Company since October, 1957. Under his presidency Douglas has become one of the world's leading producers of jet passenger aircraft as manufacturer of the DC-8, and builder of some of the nation's prime defense weapons systems: the Nike Ajax and Hercules, ground to air missiles; the Sparrow II, air-to-air missile; and the Thor IRBM.

Mr. Douglas joined the Douglas Aircraft Company in October, 1939 and supervised test flights of practically every type of aircraft produced by Douglas during World War II.

He was elected a vice president of the company in January, 1951 and a director in July, 1953.

---

changes in considerations now believed to be basic.

Since speed is one of the principal commodities offered by air transportation, Douglas Aircraft Company is designing a supersonic transport which will cruise at Mach 3. An airplane which flies at three times the speed of sound shows attractive savings in trip time on transcontinental routes, or longer, as compared with a Mach 2 or Mach 2.4 aircraft.

There is a temptation to prefer the slower transport because it can be constructed of aluminum, which loses strength at the elevated temperatures of greater speed. Historically, however, an aircraft becomes obsolete when it is superseded by one which travels faster.

Since the possibility of growth or improvement of a Mach 2 SST is limited immediately by aluminum structure, it faces the grave risk of premature obsolescence. On the other hand, an airplane constructed basically of steel and titanium can achieve a cruising speed of Mach 3 for the first generation of transports and has the capability of up to Mach 4.

To realize its speed advantage, the SST should be able to fly relatively long ranges. In the United States, non-stop transcontinental range is a necessity. It would be desirable, from the standpoint of broadening the market and from considerations of national policy, to have trans-Atlantic range. We believe this to be entirely practical. At some increase in seat-mile costs, the range could be extended to include non-stop crossings of the Pacific as well. Our present design is for a transport which will carry a capacity first-class payload 3,500 nautical or 4,000 statute miles.

As for the capacity, we have studied various sizes from 70 to 200 passengers, taking into consideration price, operating costs, productivity, scheduling frequency and airport requirements. As a result, we selected an airplane which carries approximately 100 first class passengers, seated four abreast, or from 125 to 130 coach passengers seated five abreast.

Of primary concern to airlines is the operating economy of any commercial transport. Applying the formulae presently used by the Air Transport Association for calculating costs, we find that seat mile costs of the Douglas SST would be nearly as low as on present jets.

Now the basic outline is clear: 100 first class passengers carried nonstop across the Atlantic at three times the speed of sound. Since that means a one-way trip of slightly more than two hours, the initial prediction appears to have some substance.

When these elements are established firmly, the exact geometry of the transport can be determined by aerodynamicists and structures engineers. Physically, there is a superficial similarity in the appearance of all SST designs made public, just as there is considerable similarity among subsonic transports. This is the natural result of engineers with identical technical backgrounds arriving at approximately the same design compromises.

As we know it today, the SST will have a canard arrangement, i.e., the narrow horizontal stabilizers will be at the forward end of a tubular fuselage and the supporting wings, roughly triangular in shape, at the rear. There are some advantages in grouping the engines together beneath the wings and near the trailing edge.

Our engineers believe the first engines to power the SST will be turbofans, which have shown significant fuel economy and generally lower noise levels. Eventually, thrust of these engines will be augmented by the addition of duct burning. We expect there may be as many as six engines on the prototype and development models since the ultimate engine will not be ready as early as the airframe. Our engineers believe that engines of sufficient thrust will be available by the early 1970s to require only four on a Mach 3 transport.

Let me state at the outset that our design studies are guided by the fundamental premise that the SST must be capable of being operated safely, profitably and on-schedule by the airlines. Our progress thus far leaves no doubt that the technical problems remaining unsolved will yield within a time-table which anticipates having a production transport ready for service in 1970.

High on the list of problems, however, is that of environmental noise. We know how to assure acoustical comfort for the passenger, but we are not certain what must be done to make external noise acceptable.

The Douglas SST design contemplates operating at subsonic speed until the aircraft has attained an altitude at which the shock waves or sonic boom is tolerable on the ground. While theories are plentiful on what this al-

"Mach 3" is a technical way of saying three times the speed of sound. It is derived from the name of Ernst Mach, an Austrian scientist who originated the system of using a single number to express the ratio of a speed of a body with respect to surrounding air.

A Mach number of 1.0 represents the speed of sound, which varies with altitude; Mach 0.5 is one-half the speed of sound; Mach 3.0, three times the speed of sound.

The speed of sound at sea level is 761 mph. It diminishes gradually until an altitude of around 36,000 feet, where it remains constant at 662 mph up to 80,000 feet. A Mach 3 transport will travel close to 2,000 mph.

titude should be, evidence is lacking. We believe it will be in the neighborhood of 40,000 feet, but only operating experience with a Mach 3 airplane will provide a positive answer.

Certainly, navigation and air traffic control will present problems. For the latter, we believe that ground based aids will provide a better solution than airborne equipment. A five-year study by Douglas, in which 25 electrical and electronics firms have participated for the past two years, has established the feasibility of using an electronics management system to aid flight crews in manning the SST.

Although our SST will be designed to operate from present-day international airports, terminal and maintenance facilities must be improved to minimize ground time. A delay of an hour and one-half, not unknown in present operations, would be the equivalent of losing the productivity of an entire transcontinental flight.

There are some who believe the problems touched upon here pale in the light of the financial risks inherent in a supersonic transport.

Our analysis of the world-wide market for a 100-seat Mach 3 transport indicates that during the ten-year period beginning in 1970, air traffic between points which could be served by an SST will support a fleet of 200 to 225 aircraft. This offers a satisfactory incentive for production.

Although airlines would pay from $18 million to $20 million for each transport, the cost compares favorably, on the basis of productivity per dollar, with that of current jets.

Despite these attractions, the cost of developing, producing and testing an airplane which will operate in an unexplored flight regime would be tremendous. If historical methods of financing are to be used, neither U. S. airlines nor manufacturers will have sufficient risk capital to undertake such a venture for many years.

Other countries, however, either have initiated or are about to start supersonic transport projects with government sponsorship. This poses two questions: "Can this country afford to relinquish its supremacy in aerial commerce and in the world markets for airliners?" and, "Does the economic importance of this country's aerospace industry justify some form of government participation in a supersonic transport program?"

If the answer is yes, the Federal Government might find it in the national interest to advance this country's SST program.

Or, military requirements might warrant the purchase of a modest number of supersonic jets for the Military Air Transport Service. The cost would be no greater than for the current program of modernizing MATS airlift with subsonic jets, and the yield in speed and mobility would be 300 per cent higher.

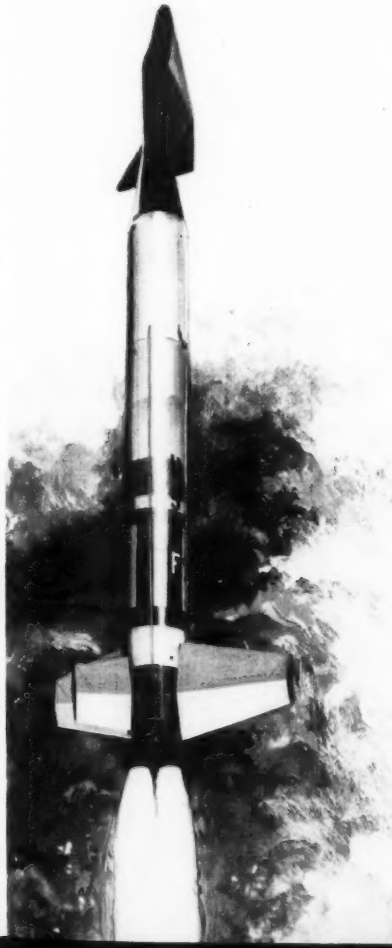
The government might also find it appropriate to intensify research and development on an SST system in its own vast research complex, augmented by R&D contracts with competent aerospace companies.

Action in any of these directions would hasten the development of an economically sound and self-liquidating supersonic transport project.

We have arrived at the time for decision.

# WHO'S WHO IN SPACE

## A Directory of Space and Missile Projects for which Companies Listed on the New York Stock Exchange have Prime or Major Contracts



THE advent of the Space Age has created a whole new defense industry. Space and missile projects represent a major portion of the nation's $40 billion annual defense budget and are expected to account for an even larger share in the years to come.

The investor interested in Space Age issues may be confused—understandably—by terms he has never heard before. Project OGO, for instance. What is OGO, what is it supposed to accomplish, what company is supervising its construction?

This directory is intended as guide to the prime and major space and missile contracts held by Stock Exchange companies. Since literally thousands of companies may be involved in some projects, it is impossible to list all of the subcontractors.

Information contained in this directory is based on material appearing in "Missiles and Rockets," copyright 1961, American Aviation Publications.

Immediately following this section, on pages 12 and 13, is a table showing pertinent financial data for companies listed in the directory. A cross reference to these companies appears on the inside rear cover.

| PROJECT | CONTRACTORS | DESCRIPTION |
|---|---|---|
| | **SATELLITES AND SPACECRAFT** | |
| ADVENT | Bendix, prime; GE, vehicle | 24-hour communications satellite; weight, 1,000 lbs. |
| APOLLO | General Dynamics, Martin, GE | 3-man spacecraft for lunar landing and exploration |
| ARENTS | General Dynamics, prime | Satellites to investigate deep space |
| BAMBI | General Dynamics, Thompson Ramo Woolridge | Satellites for intercepting enemy missiles |
| COURIER | Philco, payload; ITT, ground stations | Communications satellite; weight, 500 lbs. |
| DISCOVERER | Lockheed, prime; GE, re-entry vehicle | Satellites to test military space systems techniques |
| DYNA-SOAR I | Boeing, spacecraft and systems integrator; Martin, propulsion; Honeywell, guidance; RCA, communications data link | Orbital spacecraft |
| MERCURY | McDonnell, capsule | Manned satellite; weight, 2,500 lbs. |
| MIDAS | Lockheed, prime; General Tire, Infrared unit | Satellite to detect ICBM launchings; weight, 2½ tons |
| NIMBUS | GE, prime | Second generation weather satellite; weight, 650 lbs. |
| OAO | Grumman, prime; Westinghouse, electronic components; GE, stabilization and control | Orbiting astronomical satellite observatory with telescope; weight, 3,500 lbs. |
| OGO | Thompson Ramo Woolridge, prime | Satellites for geophysical measurements; weight, 1,000 lbs. |
| RANGER | Ford, capsule; Hercules Powder, retrorocket | Rough landed instrument capsule on moon; weight, 300 lbs. |
| SAINT | RCA, prime | Anti-satellite satellite inspection system |
| SAMOS | Lockheed, prime | Reconnaissance satellite; weight, 4,100 lbs. |
| SLOMAR | Lockheed, Martin, prime | Logistics, maintenance, supply spacecraft for space systems |
| TIROS | RCA, prime | Meteorological satellite |
| X-15 | North American Aviation, prime; Thiokol, propulsion | Rocket plane, 4,000 m.p.h. |
| | **MISSILES AND ROCKETS** | |
| ALFA | Avco, air frame | Anti-sub warfare, surface-to-underwater; conventional warhead |
| ASROC | Honeywell, prime, depth charge; GE, torpedo | Surface-to-underwater torpedo or depth charge; range, about 8 miles; nuclear or conventional warhead |
| ASTOR | Westinghouse, prime | Anti-sub underwater-to-underwater rocket torpedo; nuclear warhead |
| ATLAS | General Dynamics, prime; GE, Burroughs, American Bosch Arma, guidance; North American, propulsion; GE, Avco, re-entry vehicle | Liquid fuel ICBM; range, over 5,500 to 7,500 miles; nuclear warhead |
| BOMARC-A | Boeing, prime; IBM, Westinghouse, guidance; General Tire, Marquardt, propulsion | Ramjet surface-to-air interceptor; range, 250 miles; nuclear warhead |
| BOMARC-B | Boeing, prime; General Precision, IBM, Westinghouse, guidance; Thiokol, Marquardt, propulsion | Ramjet surface-to-air interceptor; range, over 400 miles; nuclear warhead |

| | | |
|---|---|---|
| **BOMARC-A** | Boeing, prime; IBM, Westinghouse, guidance; General Tire, Marquardt, propulsion | Ramjet surface-to-air interceptor; range, 250 miles; nuclear warhead |
| **BOMARC-B** | Boeing, prime; General Precision, IBM, Westinghouse, guidance; Thiokol, Marquardt, propulsion | Ramjet surface-to-air interceptor; range, over 400 miles; nuclear warhead |
| **BULLPUP** | Martin, prime, guidance; Thiokol, propulsion | Air-to-surface bomb; range, 3.6 miles; conventional and nuclear |
| **COBRA** | Daystrom, U.S. licensee | Solid fuel anti-tank missile; range, 1 mile |
| **CORPORAL** | Firestone, prime; Ryan, propulsion | Liquid fuel surface-to-surface; range, 75 miles; nuclear warhead |
| **FABMIDS** | General Dynamics, Martin, GE, Raytheon, General Telephone, feasibility studies | Mobile anti-missile defense system |
| **FALCON** | Thiokol, propulsion | Solid fuel air-to-air; range, 5 miles; conventional and nuclear |
| **GENIE** | Douglas, prime; General Tire, propulsion | Unguided air-to-air; range, 1.5 miles; nuclear warhead |
| **HAWK** | Raytheon, prime and guidance; General Tire, propulsion | Solid fuel surface-to-air; range, 22 miles; conventional warhead |
| **HONEST JOHN** | Douglas, Emerson Electric, prime; Hercules Powder, propulsion | Unguided surface-to-surface; range, 12 miles; nuclear warhead |
| **HOUND DOG** | North American, prime and guidance; United Aircraft, propulsion | Air-to-surface; range, 500 miles; nuclear warhead |
| **JUPITER** | Chrysler, prime; Sperry, guidance; North American, propulsion; Goodyear, re-entry vehicle | Liquid fuel IRBM; nuclear warhead |
| **LACROSSE** | Martin, prime, guidance; Thiokol, propulsion | Solid fuel surface-to-surface; range, 20 miles; nuclear warhead |
| **LITTLE JOHN** | Emerson Electric, prime; Hercules Powder, propulsion | Solid fuel unguided surface-to-surface; range, 10 miles; nuclear warhead |
| **LULU** | General Mills, prime | Small nuclear depth charge |
| **MACE** | Martin, prime; Goodyear, GM, guidance; Thiokol, GM, propulsion | Surface-to-surface; range (B model), over 1,200 miles; nuclear warhead |
| **MATADOR** | Martin, prime; Thiokol, GM propulsion | Surface-to-surface; range, 650 miles |
| **MAULER** | General Dynamics, prime | Mobile anti-aircraft and anti-missile missile |
| **MINUTEMAN** | Boeing, major contractor; North American, guidance; Thiokol, General Tire, Hercules Powder, propulsion; Avco, re-entry vehicle; AMF, ACF, rail launcher | Second generation solid fuel ICBM; nuclear warhead |
| **M-55** | Norris-Thermador | Small, short-range poison gas rocket |
| **NIKE-AJAX** | AT&T, prime and guidance; Thiokol, propulsion; Douglas, airframe | Solid and liquid fuel surface-to-air, range, 25 miles; conventional warhead |
| **NIKE-HERCULES** | AT&T, prime and guidance; Hercules Powder, Thiokol, propulsion; Douglas, airframe | Surface-to-air anti-aircraft and tactical missile; range, 75 miles; nuclear warhead |

| PROJECT | CONTRACTORS | DESCRIPTION |
|---|---|---|
| NIKE-ZEUS | AT&T, prime and guidance; Thiokol, Lockheed, propulsion; Douglas, airframe | Solid fuel anti-missile missile; range, 200 miles; nuclear warhead |
| PERSHING | Martin, prime; Bendix, guidance; Thiokol, propulsion | Solid fuel surface-to-surface; range, 500 miles; nuclear warhead |
| POLARIS | Lockheed, prime and re-entry vehicle; GE, guidance and fire control; General Tire, propulsion | Solid fuel underwater and surface-to-surface; range, 1,200 miles; nuclear warhead |
| QUAIL | McDonnell, prime; GE, propulsion; Thompson Ramo Woolridge, electronic countermeasure equipment | Bomber decoy; range, 200 miles |
| REDEYE | General Dynamics, prime; Philco, General Dynamics, propulsion | Solid fuel surface-to-air bazooka type; conventional warhead |
| REDSTONE | Chrysler, prime; Sperry, guidance; North American, propulsion | Liquid fuel surface-to-surface; range, 200 miles; nuclear warhead |
| REGULUS I | Chance Vought, prime and guidance; General Tire, propulsion | Turbojet and solid fuel surface-to-surface; range, 500 miles; nuclear warhead |
| SERGEANT | Sperry, prime and guidance; Thiokol, propulsion | Solid fuel surface-to-surface; range, over 75 miles; nuclear warhead |
| SHILLELAGH | Ford, prime | Lightweight surface-to-surface |
| SIDEWINDER | GE, Philco, prime and guidance | Infrared guidance, air-to-air; range, over 2 miles; conventional |
| SKYBOLT | Douglas, prime; Northrop, guidance; General Tire, propulsion; GE, re-entry vehicle | Solid fuel air-launched ballistic missile; range over 1,000 miles; nuclear warhead |
| SNARK | Northrop, prime and guidance; United Aircraft, propulsion | Solid fuel and turbojet surface-to-surface; range, 5,500 miles; nuclear warhead |
| SPARROW III | Raytheon, prime and guidance; General Tire, Thiokol, propulsion | Solid and liquid fuel air-to-air; range, 5.8 miles; conventional warhead |
| SUBROC | Goodyear, prime; Thiokol, propulsion; General Precision, guidance | Solid fuel underwater or surface-to-underwater; range, 25 to 30 miles; nuclear warhead |
| SS-10 | GE, U.S. licensee | Solid fuel surface-to-surface, primarily anti-tank; range, 1,600 yards |
| SS-11 | GE, U.S. licensee | Surface-to-surface and helicopter-to-surface; range, 3,800 yards |
| TALOS | Bendix, prime; Bendix, Sperry, guidance | Solid fuel and ramjet surface-to-surface; range, 65 miles; nuclear |
| TARTAR | General Dynamics, prime; Raytheon, guidance; General Tire, propulsion | Solid fuel surface-to-surface; range, 10 miles; conventional warhead |
| TERRIER | General Dynamics, prime; Sperry, guidance | Solid fuel surface-to-air; range, 10 miles; conventional warhead |
| TERRIER-ADVANCED | General Dynamics, prime; Sperry, guidance | About 100% performance improvement over Terrier |
| THOR | Douglas, prime; GM, guidance; North American, propulsion; GE, re-entry vehicle | Liquid fuel surface-to-surface; range, 1,500 miles; nuclear warhead |

| | | |
|---|---|---|
| | General Tire, propulsion | |
| **TERRIER** | General Dynamics, prime; Sperry, guidance | Solid fuel surface-to-air; range, 10 miles; conventional warhead |
| **TERRIER-ADVANCED** | General Dynamics, prime; Sperry, guidance | About 100% performance improvement over Terrier |
| **THOR** | Douglas, prime; GM, guidance; North American, propulsion; GE, re-entry vehicle | Liquid fuel surface-to-surface; range, 1,500 miles; nuclear warhead |
| **TITAN** | Martin, prime; AT&T, Sperry, Titan I guidance; GM, Titan II guidance; General Tire, propulsion; Avco, Titan I re-entry vehicle; GE, Titan II re-entry vehicle | Liquid fuel ICBM; range (Titan I), 5,500 miles; nuclear warhead |
| **TYPHOON** | Westinghouse, prime; Bendix, propulsion | Medium and long-range seagoing anti-missile missile; conventional warhead |
| **WAGTAIL** | Honeywell, prime | Solid fuel air-to-ground for low level |
| **WILLOW** | Chrysler, prime | Highly-classified missile |
| **ZUNI** | Douglas, propulsion | Solid fuel air-to-air, air-to-surface; range, 5 miles; conventional warhead |

## SPACE VEHICLES

| | | |
|---|---|---|
| **AGENA** | Lockheed, prime; Textron, propulsion | Satellite, about 1,700 lbs. after burnout; Agena-B, stop-start engine, about double fuel capacity of Agena |
| **BLUE SCOUT** | Ford, prime; Honeywell, guidance; General Tire, Hercules Powder, Thiokol, propulsion | Solid fuel multi-stage booster based on Scout components (See Scout) |
| **CENTAUR** | General Dynamics, prime; United Aircraft, propulsion; Honeywell, guidance | Pair of engines, 30,000 lbs. total thrust atop Atlas booster, capable of orbiting 8,500 lbs., launching 1,450-lb. space probe |
| **DELTA** | Douglas, booster; AT&T, guidance; North American, General Tire, propulsion | Launch vehicle, 480-lb. payload |
| **NOVA** | North American, propulsion | Clustered 6 to 12 million pound booster, plus upper stages |
| **PROJECT 3059** | General Tire, Lockheed, propulsion | Solid fuel motor in 1 to 2 million lb. thrust class |
| **SATURN** | Douglas, General Dynamics, upper stages; North American, booster and mid-stage engines; United Aircraft, top-stage engines | Series of multi-stage vehicles based on 1.5 million lb. clustered booster and various upper stages to orbit 20,000-lb. payload |
| **SCOUT** | Chance Vought, prime; Honeywell, guidance; General Tire, Hercules Powder, Thiokol, propulsion | Solid fuel four-stage satellite launcher; 200-lb. payload in orbit |
| **THOR-ABLESTAR** | Thompson Ramo Woolridge; prime; North American, General Tire, propulsion | Three-stage vehicle, orbital capability 800 lbs. |
| **THOR-AGENA** | Lockheed, prime; Textron, propulsion | Two-stage vehicle capable of orbiting more than 300 lbs.; Agena-B payload capacity to 1,250 lbs. |

## LISTED COMPANIES WHICH HAVE PRIME OR M

| Company | Sales/Revenues (in millions) 1955 | 1959 | 1960 | Net Pr 1955 | 195 |
|---|---|---|---|---|---|
| ACF Industries, Inc. † | $ 190.8 | $ 178.7 | $ 263.6 | $ 6,855 | $ 1,71 |
| American Bosch Arma Corp. | 73.8 | 120.0 | 125.5 | 3,384 | 3,53 |
| American Machine & Foundry Co. (3) | 130.9 | 236.4 | 292.8 | 4,774 | 19,88 |
| American Tel. & Tel. Co. | 5,297.0 | 7,393.0 | 7,920.5 | 664,243 | 1,113,15 |
| Avco Corp. † | 299.3 | 306.0 | 322.7 | 758 | 9,58 |
| Bendix Corp. † | 567.2 | 689.7 | 792.3 | 25,889 | 27,40 |
| Boeing Co. | 847.3(7) | 1,648.8 | 1,554.6 | 27,262(7) | 12,74 |
| Burroughs Corp. | 217.8 | 358.1 | 387.5 | 12,150 | 7,11 |
| Chance Vought Corp. | 147.1 | 254.7 | 213.9 | 4,760 | 4,90 |
| Chrysler Corp. | 3,446.2 | 2,643.0 | 3,007.0 | 100,063 | 5,43 |
| Daystrom, Inc. † | 73.8 | 76.6 | 90.6@ | 1,716 | 1,20 |
| Douglas Aircraft Co., Inc. † | 867.5 | 883.9 | 1,174.0 | 28,215 | 33,82 |
| Emerson Electric Mfg. Co. † | 40.3 | 91.3 | 125.5 | 1,228 | 3,93 |
| Firestone Tire & Rubber Co. † | 1,114.9 | 1,187.8(1) | 1,207.2(1) | 55,379 | 64,59 |
| Ford Motor Co. | 5,594.0 | 5,356.9 | 5,237.9 | 454,153 | 451,36 |
| General Dynamics Corp. | 731.2 | 1,811.9 | 1,987.7 | 22,883 | 31,05 |
| General Electric Co. | 3,463.7 | 4,349.5 | 4,197.5 | 208,908 | 280,24 |
| General Mills, Inc. † | 513.7 | 546.0 | 537.8 | 12,384 | 16,81 |
| General Motors Corp. | 12,443.3 | 11,233.1 | 12,736.0 | 1,189,477 | 873,10 |
| General Precision Equipment Corp. | 133.3 | 215.6 | 244.4 | 2,531 | 4,19 |
| General Tel. & Electronics Corp. | 698.3 | 1,081.1 | 1,178.5(8) | 49,865 | 72,25 |
| General Tire & Rubber Co. † | 295.7 | 676.9 | 753.9 | 9,705 | 26,62 |
| Goodyear Tire & Rubber Co. | 1,372.2 | 1,579.3 | 1,550.9 | 59,666 | 76,00 |
| Grumman Aircraft Engineering Corp. | 213.4 | 289.0 | 325.6 | 9,757 | 4,93 |
| Hercules Powder Co. | 226.7 | 283.6 | 336.9 | 19,012 | 23,39 |
| International Business Machines Corp. (4) | 563.5** | 1,309.8(2) | 1,436.1(2) | 55,873** | 145,63 |
| International Tel. & Tel. Corp. | 448.4 | 705.6(6) | 766.8(6) | 23,070 | 27,53 |
| Lockheed Aircraft Corp. | 673.6 | 1,304.3 | 1,332.3 | 17,332 | 8,73 |
| Marquardt Corp. | 11.3 | 69.0 | 65.5 | 335 | 1,31 |
| Martin Co. | 271.9 | 523.7 | 651.2 | 13,285 | 13,33 |
| McDonnell Aircraft Corp. † | 154.6 | 435.9 | 437.0 | 4,556 | 10,03 |
| Minn.-Honeywell Regulator Co. | 244.5 | 381.4 | 426.2 | 19,279 | 29,39 |
| Norris-Thermador Corp. † | 42.3 | 36.4 | 39.7 | 2,589 | 2,31 |
| North American Aviation, Inc. † | 816.7 | 1,044.9 | 964.2 | 32,349 | 30,73 |
| Northrop Corp. † | 283.4 | 262.9 | 233.7 | 11,739 | 7,32 |
| Philco Corp. | 373.4 | 397.8 | 400.6 | 8,423 | 7,17 |
| Radio Corp. of America | 1,050.7 | 1,395.6 | 1,494.9 | 47,525 | 40,14 |
| Raytheon Co. | 182.3† | 494.3 | 540.0 | 4,532† | 13,48 |
| Ryan Aeronautical Co. † | 41.5 | 84.7 | 122.7 | 1,551 | 2,81 |
| Sperry Rand Corp. † | 699.3 | 989.6 | 1,173.1 | 44,581 | 27,64 |
| Textron, Inc. | 189.2 | 308.2 | 383.2 | 5,497‡ | 16,64 |
| Thiokol Chemical Corp. | 13.5 | 190.2 | 171.5 | 537 | 5,53 |
| Thompson Ramo Woolridge, Inc. | 286.2 | 417.7 | 420.4 | 11,341 | 9,74 |
| United Aircraft Corp. | 697.9 | 1,081.0 | 987.9 | 31,065 | 28,63 |
| Westinghouse Electric Corp. | 1,441.0 | 1,910.7 | 1,955.7 | 42,803 | 85,94 |

* based on dividends in latest 12 months and May 10, 1961, close

** parent company only

# based on May 11, 1960 to May 10, 1961

‡ after provision for loss on disposal of properties

d deficit

@ includes European subsidiaries not previously consolidated

(1) incl

(2) incl

(3) no

(4) no

(5) bef

(6) exc

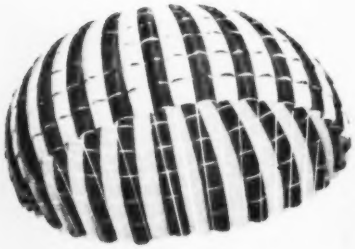
## OR MAJOR SPACE AND MISSILE PROJECTS

| 1955 | Net Profit (in thousands) 1959 | 1960 | Net Per Share 1955 | 1959 | 1960 | Price Range (Jan. 1—May 10, 1961) High | Low | Close | Cash Divs. ± | Yield* |
|---|---|---|---|---|---|---|---|---|---|---|
| 6,855 | $ 1,714 | $ 3,933 | $6.62 | $1.21 | $2.77 | $ 58½ | $ 38 | $ 57 | $2.50 | 4.4% |
| 3,384 | 3,533 | 1,038 | 1.75a | 1.81a | .51 | 24⅛ | 15¼ | 22¾ | .30a | D |
| 4,774 | 19,888 | 24,104 | .80a | 2.55 | 3.06 | 126⅝ | 85¼ | 102¾ | 1.45 | 1.4 |
| 4,243 | 1,113,152 | 1,212,966 | 4.37a | 5.22 | 5.53 | 130 | 103⅛ | 126⅝ | 3.30 | 2.6u |
| 758 | 9,588 | 10,022 | .05 | .93 | .97 | 21⅛ | 13½ | 19⅝ | .50 | 2.5u |
| 5,889 | 27,404 | 26,188 | 5.13a | 5.11a | 4.88 | 72 | 61¼ | 62¾ | 2.40 | 3.8 |
| 7,262(7) | 12,743 | 24,462 | 3.72a(7) | 1.60 | 3.07 | 48¼ | 35½ | 47⅛ | 1.30 | 2.8u |
| 2,150 | 7,110 | 9,236 | 2.19 | 1.07 | 1.39 | 38¼ | 27½ | 33 | 1.00 | 3.0 |
| 4,760 | 4,900 | 3,894 | 4.41 | 4.12 | 3.27 | 59⅝ | 38¼ | 56½ | 2.00 | 3.5 |
| 0,063 | 5,431d | 32,154 | 11.49 | .62d | 3.61 | 48 | 37⅜ | 42½ | 1.50 | 3.5 |
| 1,716 | 1,207 | 2,271@ | 2.61 | 1.32(5) | 2.48@ | 34¾ | 25⅜ | 28 | 1.20 | D |
| 8,215 | 33,822d | 19,429d | 7.43a | 8.86d | 5.09d | 38½ | 28 | 34¾ | none | — |
| 1,228 | 3,939 | 6,000 | .84a | 2.19a | 2.74 | 85 | 50 | 78 | .99a | 1.3u |
| 5,379 | 64,597(1) | 65,029(1) | 2.10a | 2.40a | 2.41 | 40¾ | 33⅝ | 40 | .99a | 2.5u |
| 4,153 | 451,367 | 427,886 | 8.51 | 8.23 | 7.79 | 86⅜ | 63¾ | 85¾ | 3.15 | 3.7u |
| 2,883 | 31,056 | 27,056d | 1.77a | 3.12 | 2.71d | 45½ | 36⅝ | 38 | 1.25 | D |
| 8,908 | 280,242 | 200,072 | 2.41 | 3.19 | 2.26 | 74 | 60½ | 63⅞ | 2.00 | 3.1 |
| 2,384 | 16,817 | 11,515 | 1.67a | 2.26a | 1.46 | 37 | 31 | 32 | 1.20 | 3.8 |
| 9,477 | 873,100 | 959,042 | 4.30 | 3.06 | 3.35 | 47¾ | 40⅝ | 45 | 2.00 | 4.3 |
| 2,531 | 4,198 | 5,313 | 2.05 | 2.63 | 3.46 | 75⅝ | 54½ | 70¾ | 1.05 | 1.5u |
| 9,865 | 72,253 | 72,430(8) | .97a | 1.13 | 1.04(8) | 32½ | 26½ | 28 | .76 | 2.7 |
| 9,705 | 26,624 | 22,785 | 2.13a | 4.84 | 4.07 | 74⅜ | 53¾ | 74 | 1.00 | 1.4 |
| 9,666 | 76,009 | 71,023 | 1.78a | 2.25a | 2.10 | 40⅜ | 33⅞ | 40¼ | .89a | 2.2u |
| 9,757 | 4,938 | 7,194 | 4.44 | 2.24 | 3.27 | 35⅞ | 29¼ | 33¾ | 1.50 | 4.4 |
| 9,012 | 23,398 | 27,165 | 2.30a | 2.72 | 2.99 | 98 | 79 | 95 | 1.30 | 1.4 |
| 5,873** | 145,633(2) | 168,181(2) | 3.46a | 7.97(2) | 9.18(2) | 733 | 580 | 700½ | 3.00 | 0.4 |
| 3,070 | 27,530(6) | 30,570(6) | 1.84a | 1.80(6) | 1.96(6) | 60⅞ | 44¾ | 59¾ | 1.00 | 1.7 |
| 7,332 | 8,733 | 42,934d | 2.91a | 1.19a | 5.80d | 45⅝ | 26½ | 41⅞ | none | — |
| 335 | 1,311 | 1,202 | .38a | .96 | .86 | 26⅜ | 19 | 22⅜ | none | — |
| 3,285 | 13,337 | 16,855 | 2.23a | 2.17a | 2.72a | 39½ | 29⅜ | 37⅝ | .90a | 2.4u |
| 4,556 | 10,038 | 12,087 | 1.33a | 2.93a | 3.55 | 39½ | 22½ | 38 | 1.00 | 2.6 |
| 9,279 | 29,399 | 26,228 | 2.98 | 4.20 | 3.74 | 170¾ | 140 | 154½ | 2.00 | 1.3 |
| 2,589 | 2,318 | 2,784 | 1.83 | 1.64 | 1.97 | 32⅜ | 18 | 30½ | .90 | 3.0 |
| 2,349 | 30,726 | 23,395 | 4.71a | 3.78 | 2.87 | 53⅝ | 41⅝ | 49⅜ | 2.00 | 4.1 |
| 1,739 | 7,325 | 7,740 | 7.89 | 4.01 | 4.22 | 64⅞ | 41½ | 63⅝ | 1.60 | 2.5 |
| 8,423 | 7,176 | 2,287 | 1.99a | 1.67 | .47 | 25⅛ | 17¾ | 24 | none | — |
| 7,525 | 40,142 | 35,117 | 3.04a | 2.59a | 1.97 | 65⅝ | 49½ | 64⅛ | .99a | 1.5u |
| 4,532† | 13,481 | 11,537 | 1.44a† | 3.60a | 2.92a | 42⅞ | 34¼a | 38⅜ | none | — |
| 1,551 | 2,813 | 2,894 | 1.13a | 1.72 | 1.76 | 24⅞ | 18½ | 23½ | .20 | 0.9 |
| 4,581 | 27,644 | 37,236 | 1.72a | .94a | 1.27a | 34⅜ | 20⅛a | 31⅞ | .59a | D |
| 5,497‡ | 16,643 | 14,168 | 1.49‡ | 3.37 | 2.93 | 29½ | 21⅝ | 25¼ | 1.25 | 5.0 |
| 537 | 5,522 | 3,563 | .19a | 1.19a | .76 | 50 | 37¼ | 48½ | none | — |
| 1,341 | 9,744 | 10,177 | 4.03 | 3.02 | 3.13 | 82⅜ | 67¾ | 74⅝ | 1.40 | 1.9 |
| 1,065 | 28,638 | 13,869 | 5.12a | 4.25 | 1.95 | 49⅛ | 37⅜ | 46½ | 2.00 | 4.3 |
| 2,803 | 85,947 | 79,058 | 1.23a | 2.43a | 2.22 | 50 | 40 | 43⅜ | 1.20 | 2.8 |

(1) includes Cuban subsidiary to July 31, 1960
(2) includes domestic operating subsidiaries
(3) no adjustment made for 2-for-1 split May 16, 1961
(4) no adjustment made for 3-for-2 split May 17, 1961
(5) before non-recurring loss of $0.70
(6) excluding Cuban operations
(7) after renegotiation
(8) includes British Col. Tel. Co.
D dividend rate decreased since May 11, 1960
u dividend rate increased since May 11, 1960
† fiscal year ended other than calendar year
a adjusted for stock dividends and splits

# SAFETY FIRST—

## SHEPARD'S FLIGHT INTO SPACE



*By* MARVIN L. KRASNANSKY
*Assistant Editor*
*The Exchange Magazine*

TAKE seven miles of electrical wire, 165 switches, dials, meters, toggles, buttons and lights; measurements refined to .010 of an inch and 20/100ths of a second; a "superclean white room" with an area of 9,000 square feet from which dust particles are removed down to .3 of a micron—the one-millionth part of a meter.

Add 4,000 companies, $135 million, mix well and season for 28 months, mostly under a seven-day-a-week, round-the-clock schedule.

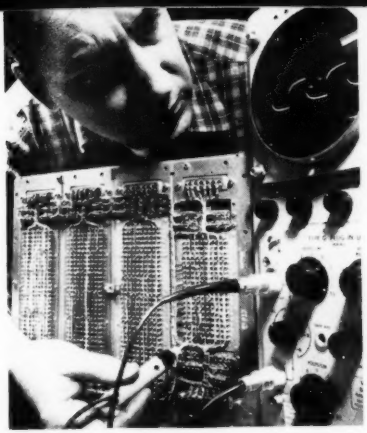
Weigh the stakes: A human life, the Race for Outer Space, the Cold War, the reputations and economic fortunes of more than a score of the nation's industrial giants, plus thousands of smaller companies.

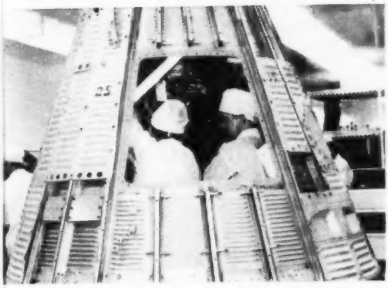
Total it all up—including several thousand minute details we neglected to mention—put it all into a 2,500-pound package crammed into a volume of 60 cubic feet, set it atop a Redstone missile.

And perhaps you can begin to grasp the enormous complexity involved in the creation of the Mercury space capsule which carried Comdr. Alan B. Shepard, Jr., on his epic journey into space.

His voyage—115 miles up and 302 miles out over the Atlantic at speeds exceeding 5,000 mph—proved many things, notwithstanding that the Soviets were first with a man in space.

Not the least of the flight's accomplishments is the knowledge that in the Mercury capsule the U. S. has a vehicle capable of carrying a human in a full orbital flight around the earth.





*Electronic brain for Mercury (top), 3,000 electronic connections; technicians assemble capsule (below).*

The same type of capsule which carried Comdr. Shepard will be used when the U. S. attempts to launch an astronaut for three 90-minute orbits around the earth later this year or early 1962.

The development of the Mercury capsule must, indeed, rate as a truly remarkable achievement of American industry, cooperating with the National Aeronautics and Space Administration.

Many of the companies involved in the Mercury project privately confide they have made little or no profit on the space ship. And one company which played a major role in the program estimates its profit at less than one per cent! But the concerns are banking heavily that the success of the venture will give them the inside track for the $1 billion man-in-space projects now on government planning boards.

The company with the biggest stake in the Mercury capsule is McDonnell Aircraft Corp., the prime contractor. Under a $135-million contract, McDonnell, working with N.A.S.A., has built 13 of the capsules, is working on 7 more, and has received orders for 6 additional vehicles.

McDonnell and the companies involved with it in Project Mercury are silent about their future space plans, but there is little doubt that already they are pushing ahead with plans and proposals for Project Apollo, the space effort that is expected to put up an orbiting multi-manned laboratory, and, around the end of the decade, set Americans on the moon. Many of the Project Mercury firms are working on Project Apollo proposals on their own despite the fact that N.A.S.A. has awarded study contracts to General Electric, Martin and the Convair division of General Dynamics.

Nevertheless, Project Mercury companies make no secret of their hopes that the Mercury spacecraft will give them a big lead over competitors for the Project Apollo contracts.

There may be good reason for their expectations. In terms of time alone, the accomplishments of McDonnell, its sub-contractors and suppliers are

a remarkable achievement. McDonnell engineers were busily working on plans for the capsule more than a year before the company was awarded the contract by N.A.S.A. in January, 1959. The first capsule was delivered 13 months later. This compares to a period of four to seven years for the design, development and delivery of an aircraft.

The feat is even more startling in view of the handicaps imposed on the program:

- Because of the stringent time limitations, development had to take place concurrently with research and testing rather than step-by-step, as is normally the procedure.
- The capsule was, of necessity, designed to be used with available rocket boosters rather than waiting for those as large and as powerful as the ones employed by the Russians. This meant that every single item that went into the capsule had to be miniaturized on a scale never attempted before.
- And, further to compound the problem, the capsule had to be designed and produced in a manner that would insure the astronaut's safety to the highest degree.

The Redstone booster used in the sub-orbital flight is generally considered the most reliable of any American ballistic missile; in the last three years this Chrysler-made rocket has experienced only one failure. Yet, for the sub-orbital shot, many of the safety margins were extended 150 per cent beyond normal tactical requirements.

And still the most elaborate safety precautions imaginable went into motion from the time the countdown started with three complete electronic systems, one automatic, one manual and operated by the astronaut, and the third at the command of the men at the ground control post—until Comdr. Shepard was hoisted from the capsule by helicopter. In addition, every system involved in the preservation of the astronaut's life was backed up by one or two others that immediately would go to work in the event of a failure.

In the event of malfunction during the countdown or prior to the separation of the capsule and booster in flight, electronic sensing devices would go into action within 20/1000ths of a second, setting off three explosive bolts which hold the capsule to the missile. Made by Olin Mathieson Chemical Corp., these bolts have been under development for five years. Each bolt can be triggered in three ways—and the shearing of only one is needed to accomplish separation. In effect, then, there are nine ways to achieve separation.

Linked to this system and designed to fire automatically is a six-foot solid propellant rocket mounted on the escape tower atop the capsule. Designed and built by Grand Central Rocket Co., a 50 per cent owned subsidiary of Lockheed Aircraft Corp., the escape rocket has a reliability factor of .999 (or one chance out of a thousand of a malfunction)—it has never failed to fire in 60 tests. In the

sub-orbital flight, the escape tower rose with the capsule for the first critical 160 seconds, then was jettisoned —by one of three systems.

In the case of an abort on the launching pad, the capsule is thrown 2,600 feet into the air and a parachute automatically pops out to float it down to earth. In a successful flight such as Comdr. Shepard's, two chutes were timed to open at two points during the descent. At 21,000 feet a six-foot drogue chute stabilized and decelerated the capsule; at 10,000 feet, the drogue disconnected and deployed the main 63-foot chute—in two steps to minimize the shock. A second chute was ready in case of failure.

The system, tested for a year and a half by the Northrop Corp., includes an elaborate series of devices to signal the location of the capsule. The drogue chute released a cloud of radar reflective metal foil strips visible for many miles by search radar. When the main chute pulled free, a small depth charge was ejected which fell into the ocean and exploded at a preset depth. Stations thousands of miles away heard the explosion and obtained a fix on the spot where the capsule hit. When the capsule set down on the water, a marking compound was automatically released.

The Garrett Corp. developed and produced the Life Support System in the capsule that enveloped the astronaut in an artificial atmosphere comparable to his normal environment on earth and maintained the pressure at about the same level as found at 25,000 feet elevation. The same system provided air conditioning which kept the capsule at 90 to 100 degrees while the temperature on the outside of the capsule was 3,000 degrees. Another air conditioning unit kept Comdr. Shepard at 75 degrees inside his spacesuit.

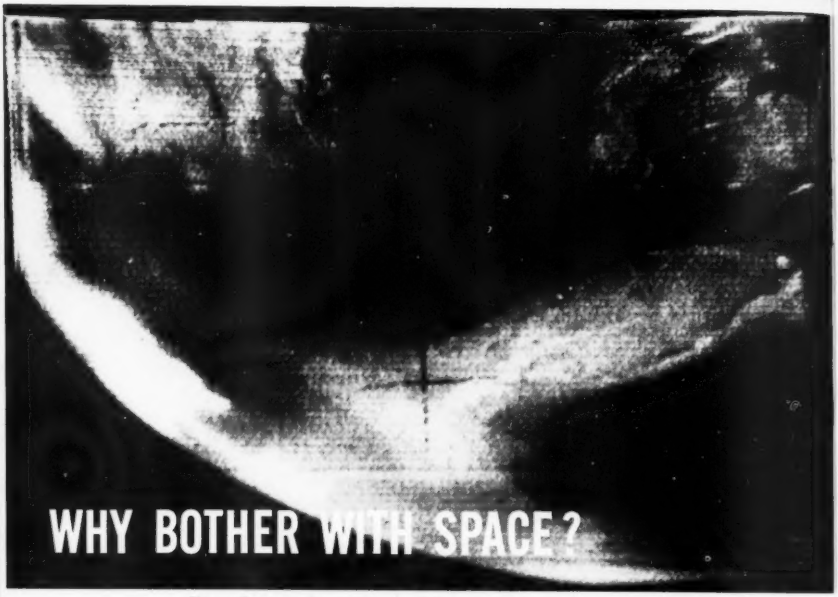
Elaborate steps were taken by McDonnell to assure the reliability of the capsule's delicate systems. This was necessary because, under certain conditions, the smallest metal particle could cause failure of a system if not removed.

To protect against these possibilities, McDonnell developed a 9,000-square-foot "superclean white room" for the assembling of the environmental and reaction control systems. The room incorporates an air conditioning filtration system that removes dust particles to .3 micron, maintains a temperature of 74 degrees and a relative humidity of not over 50 per cent.

The extent to which McDonnell went to assure the reliability of the capsule can further be measured by the 125 people assigned to quality control work—or one quality control man for every six production workers. On top of this was a team of experienced engineers and production personnel who conducted a continuing quality audit of all phases of the program.

If there remains any question as to the thoroughness of the effort that went into the project, consider this:

Before the capsule was launched, it was tested by a Bell & Howell device designed to detect leaks so small that only a thimble of air could escape in 2,000 years.



# WHY BOTHER WITH SPACE?

*Florida as photographed by Tiros weather satellite.*

*By* STUART H. LOORY
*Science Writer*
*New York Herald Tribune*

IN mythology, Icarus was a Greek with a desire to explore space. He fashioned a pair of wings from bird feathers bound together in wax, attached them to his arms and soared away from earth. Soon he flew too close to the sun and the heat melted the wax, destroying his wings.

Icarus was not seen again in ancient Athens.

Within one month this spring a cosmonaut, Soviet Air Force Maj. Yuri Gagarin, and an astronaut, United States Navy Comdr. Alan Bartlett Shepard, Jr., have succeeded where Icarus failed. They have flown through space (Gagarin to a greater extent than Shepard) and have returned to tell the world (Shepard to a greater extent than Gagarin) of their exploits.

More than Sputnik I, the Soviet harbinger of the space age, or Explorer I, the first American effort, the flights of Gagarin and Shepard have brought home the fact that earthlings are in space to stay and that the regions beyond that tenuous boundary where earth's atmosphere ends and the universe begins are destined to play an increasingly important part in the lives of men on earth. And as space becomes more important to commerce, businessmen can be expected to grow far more sophisticated about its possibilities—and investors more intrigued.

In the realm of pure science, satellites and deep space probes have been busy laying the foundation for really significant manned exploration of space. They have also helped to solve the riddles of nature on earth by taking a far-off view of this planet.

A great controversy has raged over the wisdom of pouring billions into the effort to achieve effective space exploration by man. It is well to keep in mind that man is driven to space by political, economic and social forces of great power, and he will take his science with him, extending and using it as here on earth—the model space ship.

Looking to the distant future, prominent scientists such as Fritz Zwicky, professor of astrophysics at California Institute of Technology, and Freeman J. Dyson, of the Institute for Advanced Study, have written papers speculating on the possibility of rearranging the mass of the moon and the whole inner solar system to create an extensive living space for man.

The technological advances needed to support space age sciences have already proven valuable in earth-bound pursuits and can be expected to help even more in day-to-day living. One striking example: Miniature but highly-sophisticated data sensors and radio transmitters which telemeter the performance of missiles, satellites, deep space probes and man-in-space.

Medical men envision the use of these instruments as diagnostic aids. Some doctors have conceived of surgically implanted microminiaturized sensing instruments that would keep a constant check on a person's health, radioing the information to a central computer that would keep up-to-date records and sound a danger signal when some part of a recorded individual's body begins to function improperly.

This is not far fetched. An Air Force doctor has already implanted a tiny sensor in a subject's mouth to record and transmit jaw action data.

Another space age offshoot: The harnessing of solar power. The batteries developed to store solar energy for a space probe's electronic equipment can find many applications on earth. Of course, both solar batteries and microminiature electronic components were known before the space age but their development has been greatly accelerated since Sputnik I. These two examples, of course, do not exhaust the list of useful space exploration by-products: New materials for space vehicles are under development that will find wide application in industry; new standards of product reliability have been set; rocket guidance systems can be used in other forms of transportation.

Other space age dividends include pans that can be plucked from a freezer and put into a flame immediately, finely woven stainless steel cloth (for inflatable buildings?), reinforced super-strong plastics and high-speed, lightweight computers, to name a few.

But the most exciting possibilities lie in the use of space itself—and nowhere are they more imminent than in the field of communications. American Telephone and Telegraph

Corp.—one of the several corporations interested in obtaining a franchise in space—has such faith in the possibilities that it has already begun construction of a ground station for satellite communications near Rumford, Maine, and has said it could have a satellite in orbit by this time next year, if the government were willing.

A.T.&T. is not alone in planning satellite communications systems. Other corporations interested in the field include the General Electric Co., International Telephone and Telegraph Corp. and Radio Corporation of America.

Initially the satellites would be used only for telephone, conventional teletype and perhaps television transmission. These uses in themselves would open up new vistas for international communications. AT&T has produced figures showing it would be less expensive to build a satellite communications network than to lay new transoceanic cables.

In the field of weather forecasting, the Tiros satellites have performed beyond expectations in photographing worldwide cloud cover. The information they obtain is already being fed into the Weather Bureau's forecasting computers. This is just the beginning in weather forecasting work. A future network of weather satellites will put the making of accurate long-range weather forecasts within man's grasp for the first time.

The Navy Transit satellites—so successful they have been used in targeting Polaris missiles—have shown promise in the third major application of satellites: Navigation and geodesy. Smaller satellites have ridden into orbit atop the Transits that have been used to map the positions of Pacific islands never before accurately charted. In addition to serving as man-made mariners' stars, future satellites will be used to survey inaccessible regions of earth.

Scientifically, satellites and deep space probes have made a start at measuring the important aspects of the environment beyond earth's atmosphere.

By the time an American sets foot on the moon (perhaps in 1970), unmanned satellites and probes can be expected to have made preliminary investigation of not only that natural satellite but of other planets as well. They will have told us whether life in any form exists on Venus and Mars; they may have made a start toward discovering the other intelligent life that almost certainly exists on some of the millions of other planets in the universe.

Further in the future, man himself will come into his own in space; when this will come to pass one cannot say. It would seem reasonable to state it will not occur before the end of the century but then who, at the end of World War II, was ready to predict man would fly in space by 1961?

At last the old cliche of our Western frontier has come true in a way Icarus would have appreciated. Man now lives in an age when "the sky's the limit"—a cliche that underscores the lack of boundaries on man's opportunities.

## Cross Reference to Space Directory by Company

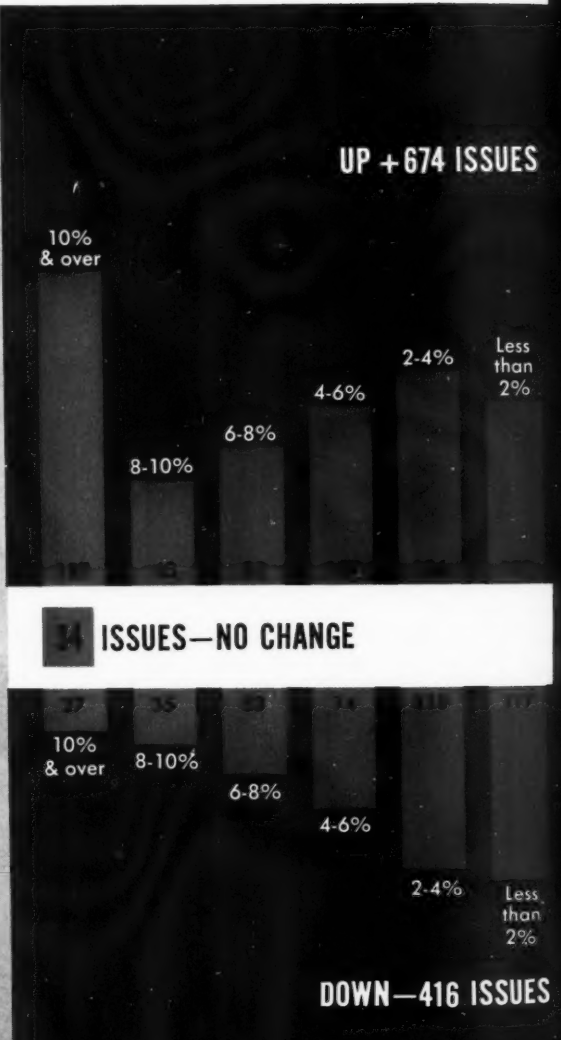
**ACF Industries**—Minuteman.
**American Bosch Arma**—Atlas
**AMF**—Minuteman.
**AT&T**—Nike-Ajax, Nike-Hercules, Nike-Zeus, Titan, Delta.
**Avco**—Alfa, Atlas, Minuteman, Titan.
**Bendix**—Advent, Pershing, Talos, Typhoon.
**Boeing**—Dyna-Soar I, Bomarc A & B, Minuteman.
**Burroughs**—Atlas.
**Chance Vought**—Regulus I, Scout.
**Chrysler**—Jupiter, Redstone, Willow.
**Daystrom**—Cobra.
**Douglas**—Genie, Honest John, Skybolt, Thor, Zuni, Delta, Saturn, Nike-Ajax, Nike-Hercules, Nike-Zeus.
**Emerson Electric**—Honest John, Little John.
**Firestone**—Corporal.
**Ford**—Shillelagh, Blue Scout, Ranger.
**General Dynamics**—Apollo, Arents, Atlas, Fabmids, Mauler, Redeye, Tartar, Terrier, Terrier-Advanced, Centaur, Saturn, Bambi.
**GE**—Advent, Apollo, OAO, Discoverer, Nimbus, Asroc, Atlas, Fabmids, Polaris, Sidewinder, Skybolt, SS-10, SS-11, Thor, Titan, Quail.
**General Mills**—Lulu.
**GM**—Mace, Matador, Thor, Titan.
**General Precision Equipment**—Subroc, Bomarc-B.
**General Telephone**—Fabmids.
**General Tire**—Midas, Bomarc-A, Genie, Hawk, Minuteman, Polaris, Regulus I, Skybolt, Sparrow III, Tartar, Titan, Blue Scout, Delta, Project 3059, Scout, Thor-Ablestar.
**Goodyear**—Jupiter, Subroc, Mace.
**Grumman Aircraft**—OAO.
**Hercules Powder**—Ranger, Honest John, Little John, Minuteman, Nike-Hercules, Blue Scout, Scout.
**IBM**—Bomarc A & B.
**ITT**—Courier.
**Lockheed**—Discoverer, Midas, Samos, Slomar, Nike-Zeus, Polaris, Agena, Project 3059, Thor-Agena.
**Marquardt**—Bomarc A & B.
**Martin**—Apollo, Dyna-Soar I, Slomar, Bullpup, Lacrosse, Mace, Matador, Pershing, Titan, Fabmids.
**McDonnell**—Mercury, Quail.
**Minneapolis - Honeywell** — Dyna-Soar I, Asroc, Wagtail, Blue Scout, Centaur, Scout.
**Norris-Thermador**—M-55.
**North American Aviation**—X-15, Atlas, Hound Dog, Jupiter, Minuteman, Redstone, Thor, Delta, Nova, Saturn, Thor-Ablestar.
**Northrop**—Skybolt, Snark.
**Philco**—Courier, Redeye, Sidewinder.
**RCA**—Dyna-Soar I, Saint, Tiros.
**Raytheon**—Fabmids, Hawk, Sparrow III, Tartar.
**Ryan Aeronautical**—Corporal.
**Sperry Rand**—Redstone, Sergeant, Talos, Terrier, Terrier-Advanced, Titan, Jupiter.
**Textron**—Thor-Agena, Agena.
**Thiokol Chemical**—X-15, Bomarc-B, Bullpup, Falcon, Lacrosse, Mace, Matador, Minuteman, Nike-Ajax, Nike-Hercules, Nike-Zeus, Pershing, Sergeant, Sparrow III, Subroc, Blue Scout, Scout.
**Thompson Ramo Woolridge** — OGO, Quail, Thor-Ablestar, Bambi.
**United Aircraft** — Hound Dog, Snark, Centaur, Saturn.
**Westinghouse Electric**—OAO, Astor, Bomarc A & B, Typhoon.

UNIV OF MICHIGAN
BUS ADMIN LIBRARY
ANN ARBOR MICH

SAMPLE COPY

# CHANGES IN PRICES OF LISTED COMMON STOCKS

***Distribution of 1,124 NYSE Issues By Percentage Price Change in Month Ended MAY 15, 1961***




| DOW JONES 65 - STOCK AVERAGE | |
|---|---|
| Apr. 14 | 229.96 |
| May 15 | 231.30 |
| Change | +0.6% |

| STANDARD & POOR'S 500-STOCK INDEX | |
|---|---|
| Apr. 14 | 66.37 |
| May 15 | 66.83 |
| Change | +0.7% |